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OCTOBER 1988

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AIR FORCE GEOPHYSICS LABORATORY
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AIR FORCE SPACE TECHNOLOGY CENTER
AIR FORCE SYSTEMS COMMAND, USAF

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JOHN R. KIDD, Colonel, USAF
Commander

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The Technical Objective Document (TOD) provides relevant planning information on AFGL's FY89 Research and Technology Program. Keywords; Technology forecasting, Defense planning, Air Force planning, Magnetosphere, Infrared surveillance, Geophysics (eds)

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TABLE OF CONTENTS

INTRODUCTION

The Air Force Technical Objectives Document (TOD) program is an integral part of the process by which the Air Force plans and formulates a detailed technology program to support the development and acquisition of Air Force weapon systems.

Each Air Force laboratory annually plans its science and technology (S&T) program in response to available guidance based on USAF requirements, the identification of scientific and technological opportunities, and the needs of present and projected systems. These plans include proposed efforts to achieve desired capabilities to resolve known technical problems, and to capitalize on new technical opportunities. The proposed efforts undergo a lengthy program formulation and review process. Generally, the criteria applied during the formulation and review are responsive to stated objectives and known requirements, scientific content and merit, program balance, developmental and life cycle costs, and consideration of payoff versus risk.

It is fully recognized that the development and accomplishment of the Air Force technical program are products of the teamwork on the part of the Air Force laboratories and the industrial and academic research and development community. The TOD program is designed to provide to industry and the academic community, necessary information on the Air Force laboratories' planned technology programs. Each laboratory's TOD is extracted from its S&T plans.

Specific objectives are:

a. To provide planning information for independent research and development programs.

b. To improve the quality of the unsolicited proposals and research and development procurements.

c. To encourage face-to-face discussions between non-Government scientists and engineers and their Air Force counterparts.

One or more TODs have been prepared by each laboratory that has responsibility for a portion of the Air Force S&T program. Classified and limited distribution TODs are available from the Defense Technical Information Center (DTIC) and unclassified/unlimited TODs are available from the National Technical Information Service (NTIS).

As you read through the pages that follow, you may see a field of endeavor where your organization can contribute to the achievement of a specific technical goal. If such is the case, you are invited to discuss the objective further with the scientist or engineer identified with that objective. Further, you may have completely new ideas not considered in this document which, if brought to the attention of the proper organization, can make a significant contribution to our military technology. We will always maintain an open mind in evaluating any new concepts which, when successfully pursued, would improve our future operational capability.

On behalf of the United States Air Force, you are invited to study the objectives listed in this document and to discuss them with the responsible Air Force personnel. Your ideas and proposals, whether in response to the TODs or not, are most welcome. Additional information on AFGL's basic needs may be found in AFGL Broad Agency Announcement. This is published annually in the Fall and is available by writing to AFGL/XOM.

MANAGEMENT OVERVIEW

Section I

LABORATORY MISSION

The mission of the

The Air Force Geophysics Laboratory (AFGL) is a world leader in geophysics, the science of the earth in its solar-terrestrial environment. It's mission is to provide technology in the area of interactions between systems and their environment. As such it conducts research, exploratory and advanced development programs in the space, ionospheric, atmospheric, optical, and earth sciences. Most Air Force systems tend to be adversely affected by environmental effects such as solar emissions, weather, earthquakes, and space radiation. The goals of AFGL scientists and engineers are to understand the way in which the environment affects Air Force systems, to mitigate the detrimental effects of the environment on the systems and, where possible, to exploit the properties of the environment - such as utilizing the ionosphere for Over-The-Horizon backscatter radar.

To perform this mission, AFGL conducts programs in the areas of the space environment, ionospheric effects, optical and infrared environment, infrared surveillance technology, the atmospheric sciences and terrestrial effects. AFGL, along with the Air Force Weapons Laboratory and the Air Force Astronautics Laboratory, comprise the Air Force Space Technology Center at Kirtland AFB, New Mexico, which is managed by the Space Division of the Air Force Systems Command, Los Angeles, California. Close liaison is maintained with all AFSC Product Divisions, with operational commands, and with other AFSC laboratories in order to identify research and technology needs and to accelerate the integration of technological advances into Air Force systems and operations.

AFGL has developed an outstanding staff of 564 technical and administrative people with a current annual budget of approximately $100 million. AFGL programs in geophysics are described in the following pages. The products of this research are transitioned into the Air Force in a variety of usable forms such as military design standards, computer-aided design tools, data bases of geophysical effects, computer models of the environment, feasibility studies, and prototype hardware and software.

The six technical divisions conduct and support basic research, exploratory and advanced development programs under their missions which are as follows:

In ~~S~~pace ~~P~~hysics, To determine the effects of the solar-terrestrial environment on current and planned Air Force systems, to conduct active space control research in order to explore the feasibility of mitigating environmental effects which degrade space systems, to develop advanced discrimination techniques, and to support space systems development and survivability.

Ionospheric physics, Optical and infrared technology, Atmospheric sciences, Earth sciences, and Aerospace engineering.

Ionospheric Physics - To investigate the physical and chemical properties of the ionosphere and the effect of these properties on the performance of current and proposed Air Force systems.

Optical and Infrared Technology - To simulate the atmospheric and celestial optical/infrared radiation, propagation and scenes for the design, development and performance enhancement of electro-optical systems, and to develop electro-optical operational tools and technologies that provide real-time decision capability for strategic and tactical commanders. To exploit the infrared region of the electromagnetic spectrum for advanced Air Force surveillance, acquisition and tracking systems applications, and to develop codes to predict the effects of natural and nuclear infrared environment upon all systems.

Atmospheric Sciences - To develop predictive and descriptive models of the atmosphere from the global to the microphysical scale, and to improve sensors and techniques to measure environmental parameters both in-situ and remotely from the ground, from aircraft and from satellite platforms.

Earth Sciences - To map the global gravity field for improved inertial navigation and guidance, and to characterize global seismic properties related to the basing of motion sensitive AF installations, and to the verification of nuclear test ban treaty compliance.

Aerospace Engineering - To support the AFGL scientists by providing balloon, sounding rocket and satellite payloads for their science missions with concentration on instrumentation and techniques in data handling, both on-board and for payload checkout on the ground.

AFGL contracts with educational institutions, non-profit organizations, and private industry for basic research, exploratory development and advanced development in the geosciences. Persons contemplating submission of a proposal for basic research to AFGL should carefully peruse the AFGL Broad Agency Announcement (BAA) which covers, in a general nature, all research areas of interest to AFGL. Requests for a copy of the BAA and/or inquiries related to AFGL basic research programs should be sent to:

Air Force Geophysics Laboratory/XOM
Hanscom AFB, MA 01731-5000

or telephone: 617-377-2598. In addition, refer to Appendix III of this document for further information on proposal preparation.

Persons who wish to submit proposals for exploratory or advanced development efforts in support of the AFGL technology program are invited to submit unsolicited proposals (in a similar format) to Air Force Geophysics Laboratory/XOP, Hanscom AFB, MA 01731-5000.

INVESTMENT STRATEGY

AFGL's approximate annual budget of $100M can be examined in three ways. One breakout shows that AFGL conducts 50% of its R&D in-house, and 50% is performed under contract with industry and universities.

Another breakout shows that AFGL invests its resources primarily in basic research (DoD Research Category 6.1) and exploratory development (6.2), and has relatively smaller investments in advanced development programs (6.3). For instance, 56% of our funding is provided by the Air Force Office of Scientific Research and Hq AFSC DCS for Technology and Plans; of that amount 24% is for basic research, 62% for exploratory development, and 14% for advanced development. Twenty-one percent is funded by the Strategic Defense Initiative Office (SDIO) and 23% is funded by other organizations, and supports primarily exploratory development-type work.

The third budget breakout is by the geophysics technology areas previously discussed under Laboratory Mission. Our largest investment (40%) is in the optics/IR area. This is followed by our investment in space (20%) and ionospheric physics (18%). The atmospheric technology areas each receive about 5% of the budget, and the earth sciences (7%).

Section II

TECHNOLOGY PROGRAM

The objective of the AFGL Geophysics technology program is to develop the capability to predict, mitigate and exploit the effects of the geophysical environment on the design and operational deployment of AF electronic, space and aeronautical systems. The performance of virtually all AF systems is affected adversely by such geophysical phenomena as magnetospheric storms, earthquakes, severe storms, clouds, ionospheric disturbances, aurora, etc. To meet the increasingly stringent AF systems requirements of improved reliability, higher accuracy and survivability, extended remote coverage and minimum life cycle cost, the geophysical environment is being addressed as an integral and interacting part of the system itself.

The program in Geophysics is divided into five thrusts which are:

Thrust 1	Space Effects on AF Systems
Thrust 2	Optical/IR Systems Technology
Thrust 3	Ionospheric Impact on AF Systems
Thrust 4	Terrestrial Effects on AF Operations
Thrust 5	Weather Impact on AF Mission

Under Program Element 62101F (Geophysics), AFGL has seven Exploratory Development projects which are:

3054	Infrared Targets and Backgrounds
4643	Ionospheric Specification
6670	Atmospheric Science and Technology
7600	Terrestrial Geophysics
7601	Magnetospheric Effects on AF Systems
7659	Aerospace Probe Technology
7670	Optical/IR Properties of the Environment

Each of these projects is aligned with one of the AFGL technical divisions, and has objectives which are listed below:

3054 - To obtain spectral and spatial aircraft and cruise missile target signatures as well as the background signatures from which these targets have to be extracted using airborne infrared sensors. The critical technology for this project is an airborne infrared target and backgrounds measurements data base in support of surveillance systems.

4643 - To determine the physical and chemical properties of the ionosphere and their effects on Air Force systems. The critical technology is satellite remote sensing of electron density.

6670 - To develop better methods of sensing, displaying, analyzing and forecasting atmospheric parameters. The critical technologies are cloud and precipitation effects, atmospheric boundary effects, climatology for system design, and global density specification.

7600 - To determine the effects of the size, shape, gravity, mass distribution and motion of the earth on missile targeting and guidance accuracy. The critical technology is to improve the gravity model.

7601 - To define the structure and dynamics of the magnetosphere and near earth-space environment. The critical technology is the space radiation environment.

7659 - To improve the capability of payload systems for balloons, sounding rockets and spacecraft. The critical technology consists of improved command and control/data processors needed to maximize laboratory data gathering projects.

7670 - To develop the data base and technology for the design and operation of infrared/optical surveillance, guidance and laser weapon systems under real world conditions. The critical technology is forecast transmission models of the atmospheric optical/infrared properties.

Also, AFGL has two major Advanced Development efforts which are:

(1) Under PE 63410F - Space Systems Environmental Interactions Technology, there are three projects:

2821 - Space Systems Design and Test Standards
2822 - Interactions Measurement Payload for Shuttle (IMPS)
2823 - Charge Control System

The objectives of these projects are:

2821 - To develop a basis for countering adverse effects of the space environment on Air Force space systems by quantifying interaction effects and developing design guidelines, test standards, and Computer Aided Engineering tools for inclusion in military standards for advanced space systems.

2822 - To design and fly a comprehensive engineering and science experimental package on the Shuttle to quantify environmental interactions with planned operational systems. This project also includes efforts to investigate possible limits on manned operations due to charging/discharging of extravehicular activity (EVA) equipment.

2823 - To design, develop and flight test an automated Charge Control System (CCS) in order to produce a spaceflight-qualified system to actively control charge buildup on spacecraft. The buildup of large differential electrical charges on spacecraft and the subsequent catastrophic discharge (arcing) can degrade system operation, cause damage to the spacecraft and reduce system performance.

(2) Under PE 63707F - Weather Systems (Advanced Development), there are two projects:

2688 - Battlefield Weather Systems
2781 - Next Generation Weather Radar (NEXRAD)

The objectives of these projects are:

2688 - To develop weather systems that will eliminate critical shortfalls in weather support to AF and Army operations. Efforts include: (a) Battlefield Weather Observation and Forecast System to gather weather data from hostile areas and process it for use by battle staff planners and aircrews in effective battlefield employment of precision guided munitions; (b) Automated Observation Subsystem to automatically sense, collect, disseminate, and display local weather conditions in real time to air traffic control facilities and operational units; and (c) Technology Transition to transition improved and new meteorological models, algorithms and techniques to Air Weather Service to support operational requirements.

2781 - To develop and test Doppler weather radar analysis algorithms for automated detection and warning of storm phenomena. The algorithms will be used by the central processor of the Next Generation Weather Radar (NEXRAD) to detect and analyze severe weather signatures. Timely warning for specific severe weather events is required to enhance flying safety and protect AF assets. NEXRAD is a joint DoD, Dept of Commerce, and Dept of Transportation program.

The AFGL technology program is conducted in-house as well as at various contractor facilities.

Section III

RESEARCH PROGRAM

Within the technology program described in the previous section, there are basic research aspects of the program which are outlined briefly below. Note that the majority of the AFGL basic research program is sponsored by the AF Office of Scientific Resarch (AFOSR).

The AFGL basic research program is strongly focused on the environmental sciences with funding coming from PE 61102F: Subelements 3, 9, 10, and 11 in the areas of Chemistry, Terrestrial Sciences, Atmospheric Sciences, and Astronomy and Astrophysics. The AFGL research activity is conducted in-house as well as at various contractor facilities.

AFGL has 18 basic research task plans which are:

2303G2 Reactions of Fast Atoms & Ions with Surfaces
2303G3 Atmospheric UV Processes

2309G1 Geodesy and Gravity
2309G2 Crustal Motion Studies

2310G1 Molecular and Aerosol Properties of the Atmosphere
2310G2 Middle Atmosphere Periodic Associated Radiance (MAPSTAR)
2310G3 Chemistry and Physics of Weakly Ionized Plasmas
2310G4 Infrared Atmospheric Processes
2310G5 Atmospheric Infrared Radiance Modelling
2310G6 Local Ionospheric Processes
2310G7 Atmospheric Prediction
2310G8 Atmospheric Specification
2310G9 Global Ionospheric Dynamics

2311G3 Solar Environmental Disturbances
2311G4 Solar-Terrestrial Interactions
2311G5 Magnetospheric Plasmas and Fields
2311G6 Particle Beams in Space Plasmas
2311G7 Infrared Astronomy

These task plans are directly responsive to the following six Air Force Systems Command (AFSC) Research Subareas:

(1) Subarea 3.1 - Space Physics Research - Research is conducted to obtain an understanding of significant environmental conditions that affect survivability and reliability of spacecraft systems as well as the propagation conditions for C^3I systems.

(2) Subarea 3.2 - Optical/IR Environment Research - Research is conducted to support the optimization of the design and performance of military systems operating in both quiet and perturbed atmospheric environments.

(3) Subarea 3.3 - Ionospheric Research - Research is conducted to define the physical and chemical properties of the Earth's upper atmosphere and ionosphere, and to determine the effects of such properties on Air Force systems operating in or through these regions.

(4) Subarea 3.4 - Earth Science Research - Research is conducted to develop geodetic and geophysical techniques and instrumentation necessary for the support of Air Force systems (surveillance, reconnaissance, target acquisition, and weapons delivery).

(5) Subarea 3.5 - Atmospheric and Meteorological Research - Research is conducted to specify and predict meteorological factors which pose threats and/or opportunities to sub-orbital Air Force vehicles and operations.

(6) Subarea 7.1 - Reconnaissance and Surveillance - Research is conducted to detect, identify, locate, count or investigate weapons, personnel, vehicles, installations, lines of communication or other features or activities by visual, photographic, electro-optical, microwave, electronic and other sensing methods.

The basic research and exploratory and advanced development interests within the laboratory mission have been organized into five thrusts: Space Effects on Air Force Systems, Optical/IR Systems Technology, Upper Atmosphere Impact on Air Force Systems, Weather Impact on Air Force Mission and Terrestrial Effects on Air Force Operations. The general and specific basic research objectives are described under each of these thrusts on the following pages. The name, branch symbol and telephone number of the cognizant staff member follow each description.

Additional information on AFGL basic research program needs are available in AFGL's Broad Agency Announcement (BAA). This document published annually in the Fall is available from AFGL/XOM.

GEOPHYSICS (GP) TECHNOLOGY AREA PLAN

Planning Guidance:

Research and Technology Planning at AFGL is based on a wide variety of inputs from DoD and USAF, as well as an understanding of where we are and where we are going. Factors that affect priorities change quickly and plans must evolve appropriately. Research and technology must address future deficiencies as well as be responsive to current field user requirements. The Geophysics Laboratory goal is to advance environmental science and technology and to understand the environmental effects on operational systems, to mitigate the detrimental effects of the environment, and where possible, to exploit the properties of the environment.

The geophysics science and technology is driven by strong interactions with the large number of customers throughout the Air Force and the DoD and the documented requirements they generate. (see section 6 below). Further, these are directly related to "Defense Guidance", the DoD Strategic Plan for developing and employing future forces, which contains the national DoD objectives.

The science, technology and planning staff consult on a continuing basis with System Program Offices and Plans Offices at (AFSC, SD, STC, BMO, ASD, AD, SAC, TAC and SPACECOM), the Mission Area Plans and the Hq AFSC/XT Science and Technology Program Document. Both technology push and systems pull are identified and utilized in focusing the laboratory programs. Operational commands requirements are also transmitted through the Air Weather Service which has the mission of providing environmental support to the operational commands. The AWS staff meteorologist with representatives at every AFSC product division and Air Force Operating Command, represent an additional channel for identifying users' requirements and for transitioning AFGL-generated science and technology AF customers.

Technical Deficiencies:

A major deficiency is the inability to characterize and predict the interaction of operational systems with their space environment. Lack of detailed, specific knowledge of the interaction of operational systems with their space environment is a major deficiency. For radiation damage, the energetic particle environment and its change with time is insufficiently known, thereby creating major uncertainties in shielding design. This impacts not only the cost of pounds-to-orbit but the total system design by constraining the payload weight. The severity of spacecraft charging varies with the electrical coupling to the ambient plasma and the rapidity of charging onset, and is influenced by the on-orbit aging of spacecraft surface material properties. Sensor degradation through contamination may result from a dirty spacecraft as well as from specific hostile acts. US space system on-orbit performance is degraded by both natural and man-made effects. The advanced VLSI microelectronics finding their way into spacecraft now are threatened by the energetic particles from cosmic rays and the Earth's radiation belts. As the basic chip cell size decreases, its relative vulnerability to single event upsets (SEUs) produced by the passage of a single energetic particle through the chip increases markedly. The particles causing SEUs may have their origin in galactic or extragalactic stars or in our own sun; they may pass once through a spacecraft and be available for further interactions in the same or other spacecraft. Solar

disturbances can have a major impact on AF space operations. The expansion of science and technology efforts to develop a capability to predict these disturbances is crucial to the creation and operation of robust space assets. Specification and prediction of the natural space environment and the ability to discriminate natural from artificially produced backgrounds is essential to the development of mitigation techniques and to the establishment of discrimination abilities.

HF/VHF/UHF radars and communication links must be able to operate during natural disturbances as well as in post-nuclear environments. Ionospheric specification is required for optimal system design as well as operational efficiency. Advancement in ionospheric enhancement technology is required to improve radar and communications capabilities, as well as to increase the survivability of RVs. Reentry blackout of communications is also a significant problem. Space surveillance systems may be blinded or disrupted by hostile action. Use of UV sensor wavelenghts may correct this problem. The deficiency of not being able to locate the missile hard body (versus its extended plume signature) which complicates missile kill tracking and assessment may also be lessened by the use of UV sensors.

Air Force efforts to develop a mobile ICBM force require a means for rapid survey of launch areas for missile intertial system initialization. Detailed knowledge of the earth's gravity field would reduce errors inherent in current inertial systems. The Air Force's ability to detect and track low-RCS air-vehicle targets must be improved in a broad range of technologies--innovative approaches to solving this problem are needed.

Major deficiencies exist in cloud forecasting to support requirements of surveillance missions (cloud specification and analysis to provide input to numerical models) and in high-resolution global meteorological observations to provide input for numerical weather prediction schemes for remote or hostile areas worldwide to support strategic operations.

Technical Opportunities Assessment:

The development of the CRRES satellite has created a significant opportunity to relate quantitatively (for the first time) the degradation of advanced spaceborne microelectronics to the dynamically changing ambient radiation and to calibrate ground testing techniques, thereby enabling the optimal use of these devices in future space systems. The development of space environmental detectors for the Defense Meteorological Satellite Program will provide the AF and DoD with the first continuous monitoring of the space environment. This capability will provide the AF with an ability to distinguish engineering failures from environmentally induced systems degradation. It will also provide the baseline specification to be utilized to advance discrimination capabilities and to optimize C^3I technologies. An automatic spacecraft charge control system for geosynchronous orbit satellites will provide AF and DoD space systems with an important new tool for detecting damaging charging events and mitigating charge buildup by clamping the spacecraft to the environment through the generation of a low energy plasma cloud around the spacecraft.

The new and highly sensitive solid-state photomultiplier (SSPM) IR detector should be exploited for the detection and tracking of low-observable (including low radar cross-section) targets. Optical (before the detector) clutter suppression techniques should be exploited to reduce the weight and cost of on-board computer processing currently used to electronically suppress clutter for surveillance and tracking systems.

The use of chemical quenchants to reduce radar-cross-sections and/or communication blackouts of reentry vehicles and NASP should be exploited. Creation of artificial ionospheric mirrors provides an opportunity to allow OTH radars to detect close-in and reduced radar-cross-section targets, greatly enhancing C^3I capabilities. UV techniques for remote sensing of the ionosphere to obtain electron density profiles over areas of inaccessibility, and for nonblindable, non-cryogenic surveillance sensors must be pursued. Empirical orbit prediction models need to be replaced by more accurate physical models.

The use of superconducting technology for improved inertial guidance and gravity survey systems would provide mobile ICBM systems, such as the rail garrison basing concept, with gravity information easily and quickly, and at low cost. Improvements in the accuracy of weapons delivery is a continuing effort contributing to the effectiveness of our existing strategic forces and permitting the alternative of a non-nuclear discriminating strategic attack capability. AFGL's exploratory development effort in using seismo-acoustic techniques to detect, track, and identify low-observable air vehicles would provide the Air Force a capability in support of the Air Defense Initiative.

References:

- AFSTC Military Space Systems Technology Plan
- DoD Defense Guidance, FY 1988-92
- BMO Future Systems and Technology Workshops
- AF Spacecom Briefing - Space Technology
- DoD Atmospheric Transmission Plan
- MJCS 154-86, Military Req for Defense Envr Satellites
- SDI WPD 24, Space Surveillance and Tracking System
- SDI WPD 32.1, Integrated Phenomenology System
- SDI WPD 32.2, Surveillance, Acquisition, Tracking and Kill Assessment
- USAF Global Assessment, FY90-94
- Hq Air Weather Service Geophysical Requirements (GRs)
- BMO Strategic Missile Technology Requirements, Jan 1988
- AFSC Forecast Planning Guidance, December 1985
- Technology Plan for the Strategic Defense Initiative,
- Feb, 1984
- Project Forecast II, Final Report, June 1986
- Exploratory ICBM Concepts, 1985
- AFSC/MAC Weather 2000: Air Force Weather Mission Analysis
- Statement of Operational Need

AC/ADCOM	SON 010-71	OTH Backscatter Radar for Defense
MAC	SON 002-80	Ionospheric Sensing
SAC	SON 008-79	Adaptive Wideband HF Communications
SAC	SON 015-86	Advanced Sky Wave Communication System
SPACECOM	SON 008-85	Survivable HF/VHF Systems
SC	SON 001-84	Space Intelligence Systems
TAF	SON 308-84	Improved Infrared Search and Track Capabilities for Tactical Defense
MAC	SON 001-83	Space Environmental Monitoring
SAC	SON 001-83	Advanced Single-RV ICBM
SAC	SON 009-81	Non-Nuclear Discriminating Strategic Attack Capability
AFTAC	SON 008-85	Auxiliary Seismic Detection and Analysis Capability

Relationship to Other Programs

1. AIR FORCE

AFWL - Joint development for an internal discharge monitor to be flown on CRRES (Combined Radiation and Release Experiment Satellite). Joint development and test of high-energy-radiation codes. Participation in the Relay Mirror Demonstration Program by providing atmospheric turbulence measurements and forecasts. Support to the Laser ASAT program through development of laser propagation codes and quantification of atmospheric absorption.

AFWAL - Joint development of space-flight experiments for the space-flight testing of advanced space power requirements. Avionics Lab provides smart weapons performance studies and models in support of AFGL's Tactical Decision Aids program. Results of the AFGL basic research in superconducting inertial instrumentation will be transferred for eventual development leading to a prototype system. AFWAL develops UV detectors, and AFGL develops UV instruments (and makes measurements) of missile plumes and atmospheric backgrounds.

AFAL - Supports the development of rocket plume radiance models by defining the spectroscopic parameters of the line-by-line emissions of the rocket exhaust products. Obtain UV background and plume measurements for use in AFAL development of plume models for SDIO programs.

RADC - Joint experimental program to measure spacecraft phenomenology using optical telescopes at the Air Force Maui Optical Site. Contamination effects on large optics will be detected/ mitigated for SDIO. Provide ionospheric properties required for evaluation of radio propagation for Air Force C^3 systems.

BMO - Results of the superconducting program will be transferred to enhance ICBM inertial guidance mechanisms, and methods of reducing RV RCS. Technology is being developed for fixed and mobile launch site evaluation and countermeasures.

ESD - Joint exploration of feasibility to create artificial mirrors in the ionosphere for expanding the usefulness of OTH radars. Provide ionospheric measurements and models for use in the design of C^3 systems such as OTH and BMEWS.

ADI - The technique of augmenting air (acoustic)-to-ground (seismic) coupled signatures is being developed as a detection alternative for low-observable vehicles.

SD - Design, develop, and integrate space weather sensors for DMSP operational spacecraft. Assessment of the utility of man in space and environmental interaction hazards to astronauts. Provide charging and contamination models for satellite system designers. A seismic/acoustic study of the shuttle launch environment to determine the effects of a launch on ground-support facilities. Provide ionospheric scintillation measurements and models for design of the GPS system. AFGL coordinating installation of a GPS receiver on the shuttle with the GPS SPO.

AF SPACECOM - AFGL, as a member of the Imaging Analysis Console Working Group will input satellite interactions phenomenology models to Space Command. Goal is to provide NORAD with a satellite mission payload assessment cap[illegible]ty.

AEDC - Spacecraft contamination chamber facilities to characterize out-gassed molecules.

AFATL - Plume exhaust modeling of axial and divert thrusters.

ASD - Joint participation in the Infrared Search and Track (IRST) program to develop improved airborne infrared sensors for operational useage.

AFTAC - AFGL conducts support programs addressing technical deficiencies in seismic event source location and characteristics for monitoring nuclear test monitoring.

2. ARMY - In collaboration with ASL, AFGL is pursuing the development of algorithms to estimate the probability of cloud-free arcs needed for SDI ground-based laser siting studies. Collaborate in ground-based, high-energy-laser-site characterization measurements and models.

3. NAVY - Conduct joint space flight experiments with NRL in the area of solar activity and magnetospheric dynamics. Provide atmospheric turbulence measurements, models, and operational forecast tools to NAVSEASYSCOM as part of both SDI WPD 170 and the Skylite Program. Provide phenomenology support towards the development of a high-spectral-resolution Fabry-Perot limb scanning sensor. Jointly develop, with NRL, technology to remotely sense electron densities in the ionosphere for eventual DMSP application. Collaborate with the Space and Naval Warfare Systems Command on SDIO WPD 170 to validate a cloud-free line-of-sight simulation model.

4. DARPA - Perform space-based measurements and develop energetic particle codes to assess microelectronic performance in nuclear and naturally occurring space environments. Provide aircraft, missile, and ground-based target signature information to DARPA. AFGL-FISTA provides the lead aircraft for the TEAL RUBY program by proper aircraft positioning, by providing a calibrated target, and by measuring apparent radiances of targets and backgrounds under the same conditions seen by the satellite. AFGL is the technical agent for the seismology portion of negotiations for a comprehensive Nuclear Test Ban Treaty.

5. DMA - Delivered an airborne gravity gradiometer which is to be used for gravity surveys in USAF and Navy ICBM launch areas. Providing data to improve global gravity models and determination of intercontinental baselines.

6. DNA - Provide all rocket and shuttle experiment flight data for use in the DNA NORSE Code development of post-attack nuclear scenarios. Perform measurements of disturbed ionospheric conditions to assist DNA in quantifying the effects of nuclear disturbances on radio and radar signals. Develop and improve post-attack dust cloud model validation studies.

7. SDIO - AFGL is a major member of the SDIO Phenomenology Steering and Analysis Groups (PSAG) charged with performing critical assessments of and providing guidance for key space experiments, technical analyses of phenomenological databases, and program planning to integrate relevant measurement and modelling activities within SDIO. In addition, AFGL provides necessary integrated phenomenology data, models, scenes and analysis of the backgrounds and targets needed by SDIO for various purposes, including the development of the SDIO scene generator for validating SDIO products. Efforts by AFGL and SDI contractor organizations will provide UV Earth limb measurements leading to a UV database, as well as UV plume models. In the IBSS program, AFGL is responsible for measurements of emissions of rocket plumes, Earthlimb backgrounds, gas releases and spacecraft contamination, as well as for expanding the spectral coverage of space surveillance systems into the UV region. AFGL is developing a space power system interactions code for use in designing highpower, space-based SDIO systems.

8. NASA - Interdependent programs which have resulted in satellite sensor development and new space models, specifications, and codes for environmental interactions. Joint AF-NASA CRRES program will provide radiation models and determine radiation effects on microelectronics. The chemical release part of the program will actively modify the ionosphere, trace magnetic field lines and inject plasma into the magnetosphere. NASA is the integrating agency for the Spacecraft Kinetic Infrared Test (SKIRT) experiment and will receive the measurement data. Joint effort with NASA GLOBE program to conduct measurements to define the global distribution of atmospheric aerosols. AFGL's superconducting six-axis accelerometer will be used in conjunction with the NASA three-axis gravity gradiometer for platform control during the tests of the NASA gradiometer. NASA/KSC will gather data on clear-air convective initiation events in tropical/ sub-tropical environments to provide the basis for AFGL analytical studies to establish prediction criteria.

9. OTHER

a. NATO: AFGL is the Air Force Representative to the Advisory Committee, Research Study Group (AC/243, Panel IV/RSG.8) that coordinates research on the influence of the atmosphere on E-O propagation through fog, rain, and aerosols.

b. Sandia National Laboratory: Joint programs in support of FTD needs for laser scattering, propagation, and detection.

c. FTD, DIA - AFGL provides expert analysis and consultation on ionospheric effects.

d. NOAA/ERL - Participates in evaluation of next generation doppler weather radar algorithms developed by AFGL through IOT&E experiments.

Section IV

Research and Technology Program - Descriptions

SPACE EFFECTS ON AIR FORCE SYSTEMS

GENERAL OBJECTIVE: The general objective is to define the impact of the Earth's space environment on Air Force systems and to achieve a capability for specifying, predicting, mitigating. and exploiting the effects of the space environment which can disrupt or degrade Air Force operational systems. Of particular interest to USAF operations are the forecasting of solar and interplanetary geomagnetic disturbances; understanding and specification of the earth's radiation belts; high latitude particle, current, and field effects; and environmentally induced adverse effects on large, high-power space systems. The problem of spacecraft contamination in the form of chemical, particulate, and optical contaminants which impact the operation of space-borne sensing systems is a new area of technology development. Within this objective there are six major science and technology areas; Space Radiation Effects, Space Weather, Space Environment Control Technology, Space Systems Environment Interactions Technology, Spacecraft Contamination, and Strategic Space Science and Technology.

SPACE RADIATION EFFECTS

This research is directed toward the development of dynamic models and updating of static models of the Earth's radiation belts. Theoretical studies and computer simulations of radiation belt transport processes are required. Results from a joint Air Force - NASA space mission must be analyzed. The research also focuses on the morphology and dynamics of auroral electron and ion precipitation using existing and future satellite data bases. The research will specify the conductivity of the high-latitude ionosphere as a function of geomagnetic coordinates, season, and levels of magnetic activity. Studies of the thermospheric heat budget will be conducted using existing measurements and models of global Joule heating and particle energy deposition. Areas to be emphasized will be the development of models of the polar cap and auroral oval arcs; substorm phenomenology such as westward traveling surges and micropulsations; and high-latitude boundary dynamics.

Mr. Edward G. Mullen, PHP (617-377-3214)

SPACE WEATHER SPECIFICATION/FORECASTING

Magnetosphere

This research is directed toward analytical, empirical and experimental studies required for understanding the dynamics of nearearth space environments created by solar driven processes. The focus is on the morphology and dynamics of magnetospheric plasmas and their transfer of energy and forces to the near-Earth space environment, especially during magnetic storms and substorms. The long-range goal is to develop the capability to treat the solarterrestrial system as a predictable weather system. Specific elements include the following: (1) Improved measurement programs to map the space environment plasma, magnetic

fields, and electric fields. (2) Theory and analysis to estimate the coupling and acceleration processes such as auroral and polar cap current systems, wave-particle interactions, and the causes of plasma irregularities. (3) Analyses of satellite particle, field, and plasma measurements which will improve the understanding of energy and information transfer between regions. (4) Modeling of the dynamics of the global distribution of electric fields, currents, and thermal plasmas to enhance our ability for specification and prediction of magnetic storm storm effects on the environment. (5) Theory and analysis to identify critical physical mechanisms, both macroscopic and microscopic, which control energy transfer from the solar wind to the magnetosphere and then on to the near-earth region.

Dr. Nelson C. Maynard, PHG (617-377-2431)

Solar Hazards Predictions

This research is directed toward the understanding and prediction of solar activity. Areas to be investigated: studies to improve ground-based solar observational techniques; instrumentation for a satellite dedicated to the study of solar emissions which determine the shape and content of the magnetosphere; instrumentation capable of producing high-resolution images of solar features in near real-time, relatively free from distortions produced by the earth's atmosphere; theoretical studies dealing with emission mechanisms and energy transport in white -light solar flares, and their relationship with energetic proton emissions; high-speed solar wind streams; solar-energy storage, transport and release mechanisms; solar seismology; the correlation between solar radio bursts and geomagnetic disturbances; use of coronagraphic data for prediction and understanding of solar activity; instrumentation to detect interplanetary disturbances in white-light and studies to interpret and mold the data; solar-like activity on other stars; and ground-based observations of interplanetary disturbances.

Dr Stephen Keil, PHS (505-434-1390)

SPACE ENVIRONMENT CONTROL TECHNOLOGY

The goal of this research is to increase basic understanding of space plasma processes and to actively mitigate deleterious effects of energetic radiation on systems' performance. Areas to be emphasized include: injection of small quantities of particle-beams, chemicals or electromagnetic waves into various space plasma environments; development of the physical theory and the simulation of beam, chemical, and wave interactions with unstable space plasmas; computer and laboratory simulations to develop quantitative definitions of injection parameters required for maximum observable effects in a wide range of space environments. With the achievement of these goals, we anticipate that we would be able to design, fabricate, and test space-based accelerators and related diagnostic systems.

Dr William J. Burke, PHA (617-377-3980)

SPACE SYSTEMS ENVIRONMENTAL INTERACTIONS TECHNOLOGY

Exploratory Development Program

Principal goals of this research are to develop the capability for understanding the interactions of large and/or high-power space structures with the space environment and to develop techniques for mitigating these effects on mission spacecraft. Also to identify safety issues to astronauts due to the space environment coupling into life support and mobility systems. Basic research interests include: time dependent response of space plasmas to non-linear perturbation, geomagnetic effects on plasma probes, plasma interactions including sources and sinks, wave particle effects in the spacecraft environment, critical ionization velocity, discharge phenomena, transition regime plasma and gas kinetics, and plasma chemistry and radiation. Numerical models play a fundamental role in these investigations. Major problem areas of applied interest include: differential charging, astronaut hazards due to auroral electron beams, power loss and damage due to coupling between plasmas and space power systems, shuttle glow, ground and space-born imaging of space environment interactions, and chemical releases to study critical ionization phenomena in low Earth orbit. A comprehensive understanding of this wide spectrum of space system environmental interactions requires the application of theory, modeling, laboratory, and actual space experimentation.

Mr Charles P. Pike, PHK (617-377-3177)

Advanced Development Program

This science and technology program develops the scientific groundwork required for countering adverse effects of the space environment on Air Force space systems. New systems will not meet the most stringent requirements for survivability, reliability, autonomy and long-lived operation unless they are designed to mitigate these environmental effects. Environmentally induced problems identified by recent experiments from Shuttle and other satellites include: malfunctions of on-board microelectronics; spacecraft charging/discharging during polar orbit; possible limits on manned operations due to charging/discharging of extra-vehicular activity equipment; decreased materials stability associated with increased contaminants; deformation of radar antenna or large-system optics; power loss and materials damage of large solar arrays caused by interaction with space plasma; and significant materials degradation. This program's goals is to quantify interaction effects and develop design guidelines, test standards, and computer-aided engineering (CAE) tools and a spaceflight-qualified charge control system to system developers.

LTC John A. Gaudet, PHE (617)377-3989)

SPACECRAFT CONTAMINATION

The goal of this research is the develop a code for the prediction of the effect of spacecraft contamination on the operation of spacecraft in low earth orbit. The proper development of this code will involve experimental and theoretical studies of: phenomena which lead to enhanced ionization in the vicinity of spacecraft; in low earth orbit reaction of fast ambient gas species with spacecraft surfaces; surface changes which take place in this interaction; reaction of fast

ambient species with gaseous products of outgassing and thruster firings; reactions and interactions which lead to the generation of glow and extended luminosities on spacecraft in low earth orbit; particulate densities and processes which lead to their formation in this environment; and codes and models which are designed to quantify these effects.

Dr Edmond Murad, PHK (617-377-3176)

STRATEGIC SPACE SCIENCE AND TECHNOLOGY

The goal of this work is to model the plasma and optical radiation generated by space vehicles moving and operating in space. Phenomenology models will be developed to characterize the signatures of spacecraft including contaminants, surface glows, anomalous ionization processes, outgassing, and engine firing exhaust products. Ground-based and space-based optical sensor data will be fused into models characterizing these processes. Air Force Space Command requires this information for developing a mission payload assessment capability, and SDIO for decisions on mid-course surveillance systems.

Dr Edmund Murad, PHK (617-377-3176)

OPTICAL/IR SYSTEMS TECHNOLOGY

GENERAL OBJECTIVE: The general objective is to measure and predict the optical and infrared geophysical environment and its effects on Air Force and DOD surveillance, reconnaissance, and weapons guidance systems. The environmental properties of particular concern are the optical/IR background emission of the earth, the atmosphere, the celestial sky and near-earth space, emission of the earth, the atmosphere, the celestial sky and near-earth space, and the transmissivity of the atmosphere at wavelengths pertinent to the operational systems mentioned above. Within this objective there are six major research areas: Target Detection Technology, Airborne Measurements, Auroral/Airglow/Nuclear Backgrounds, Visible/Infrared Atmospheric Propagation, Infrared Celestial Backgrounds, and Lidar Technology Development for space.

TARGET DETECTION TECHNOLOGY

Basic research in this area requires the development of innovative means of enhancing the infrared signatures of low-observable targets relative to infrared atmospheric backgrounds. Improvement in the detectability of targets relative to naturally occurring or artificially induced infrared backgrounds may be pursued by enhancing the target's signature, by suppressing the IR background, or by combining aspects of each approach. Emphasis in this area is on increasingly smaller spatial and temporal scales. The spectral region of interest covers the short-to-long-wavelength infrared.

Dr A.J. Ratkowski, OP (617-377-4910)

AIRBORNE MEASUREMENTS OF TARGETS AND BACKGROUNDS

The Flying Infrared Signatures Technology Aircraft (FISTA) is an NKC-135 aircraft used to obtain inflight infrared data on targets and backgrounds with a variety of spectrometers, thermal imagers, and radiometers. Using periscope mirrors, target aircraft can be viewed from nose-on, tail-on, top, or bottom aspects; and, without periscopes, side aspects while in flight. Measurements are made of terrestrial and sky backgrounds or of ground or ocean targets collected under a wide variety of meteorological conditions. The mission of FISTA is to make inflight, state-of-the-art infrared technology observations to evaluate and demonstrate sensor performance, clutter levels, target detectability, etc. Instrumentation is well calibrated so that data base information can be compared among targets, atmosphere, and backgrounds. New phenomenology observed is investigated for the purposes of development and verification of computer programs that model related phenomena.

Mr Brian Sandford, OPF (617-377-3370)

AURORAL/AIRGLOW/NUCLEAR BACKGROUNDS

Basic research in this area requires development of innovative means of measuring the infrared and associated optical emissions from naturally occurring and artificially induced atmospheric disturbances. Emphasis is on spatial and temporal scales which are at the forefront of current research. State-of-the-art spectral resolution in the short-to-long wavelength infrared is essential.

Dr A.J. Ratkowski, OP (617-377-4910)

VISIBLE/INFRARED ATMOSPHERIC PROPAGATION

This research is concerned with the modeling, measurement and analysis of the scattering, absorption, and radiative processes in the UV through the mm spectral range over the altitude regime from 0 to 120km. It includes experimental and theoretical high resolution molecular spectroscopy (line parameters and their temperature dependence) for both normal atmospheric conditions and excited background signatures. Additional emphasis is placed on molecular collision dynamics as it effects line shape, continuum, and collision induced spectra. The radiative implications of atmospheric path characterization (description of temperature, density, and molecular/particulate constituent profiles and their variability) on active and passive remote sensing instrumentation is also a major research activity. This involves both validation of the predictive capability through direct analysis of atmospheric measurements and the design and implementation of improved model algorithms. Theoretical studies of turbulence include optical propagation, nonlinear optics and chaos dynamics. Measurements include insitu and remote sensing of the optical turbulence structure constant and parameters of which the structure constant is a function. Optical turbulence modeling includes simulation, site-characterization, and forecasting. To develop predictive models of the atmospheric aerosols and their optical/IR properties it is necessary to carry out experimental and theoretical studies of the aerosols and these properties and how they are transported by the

atmospheric motions and modified by various physical processes within the atmosphere. Theoretical studies are required on radiative tranfer within scattering and absorbing atmospheres (especially the effects of aerosols and clouds), not just for the propagation effects of the atmosphere, but also for predictions or modeling of the sky or ground radiances due to scattered solar (and/or lunar) radiation from the atmosphere. Particular emphasis will be given to multiple scattering, laser backscatter and off axis scattering from laser beams.

Dr Donald E. Bedo, OPA (617-317-3667)

LIDAR TECHNOLOGY DEVELOPMENT FOR OPERATIONAL SENSORS

The technology being developed is the capability for remote sensing of atmospheric properties from space, based on lidar concepts. The research requirements are to develop eye-safe, long lifetime lasers for years of unattended service in space. Hardware requirements include agile optics, on-board data processing at very high data rates, on accurate laser beam pointing, and point-ahead angle compensation. Aerosol backscattering provides the mechanism for doppler wind measurements. Atmospheric constituents such as water vapor and ozone and other minor constituents which absorb radiation and affect the performance of electro/optical weapons systems can be measured using differential absorption lidar. As the laser system hardware is developed, engineering and proof-of-concept tests will be performed from high altitude balloons. Technical guidance, demonstration programs and data management algorithms are developed and provided to the DMSP office at SD.

Dr Donald E. Bedo, OPA (617-377-3667)

IR/CELESTIAL BACKGROUNDS

The goal of this research program is to characterize the IR celestial background. The infrared spectral, spatial, and intensity properties of celestial sources are to be determined with emphasis on the classification of these sources and their relationship to galactic and cosmic structure. Theoretical and observational studies of the properties of background sources will be carried out using cryogenic sensors flown on the shuttle and dedicated orbital platforms. Advanced IR mosaic detector focal planes are developed and used for high spatial resolution studies. The majority of our effort focuses on phenomenological and astrophysical modeling of the intrinsically and apparently bright sources of infrared emission in the celestial background.

Dr Stephen D. Price, OPI (617-377-4552)

IONOSPHERIC IMPACT ON AF SYSTEMS

GENERAL OBJECTIVE: The ionosphere is a ring of ionized plasma surrounding the earth at altitudes from about 60 km to 1000 km. The ionosphere influences most radio signal propagation, and therefore, strongly affects the operation of many Air force systems. The objective of this thrust is to define the physical and chemical characteristics of the ionosphere and to develop an understanding of how

it affects the propagation of electromagnatic radiation. Some of the specific areas of research interest in this thrust include, ionospheric composition and dynamics, ionospheric disturbances, ionospheric effects, ionospheric circulation, charged/ neutral particle characteristics and interactions, ionospheric modifications, and ultraviolet emissions and absorption.

GLOBAL IONOSPHERIC IMPACT ON C^3I

The objectives of this work area are to develop global models of ionospheric scintillation, including not only specification but also prediction. This latter requirement necessitates modeling of global scale electron density profiles and plasma convection and determination of the association of the background bulk ionospheric plasma processes and other source functions with small scale ionospheric irregularities. These associations are made from various ground-based and airborne transionospheric propagation data, incoherent scatter radar profiles of ionospheric parameters, satellite in-situ data, and various radio and optical sensors. Effects of transportion structuring of large scale plasma density enhancements in the high-latitude ionosphere are studied experimentally. Various plasma instability mechanisms leading to the formation of small scale irregularities are investigated. In addition, global models of these ionospheric parameters will be used to generate semi-empirical ionospheric specification/ forecast models of the low-, mid-, and high- latitude regions for technology transition to the Air Weather Service. The combination of theoretical and experimental work is designed to lead to a better understanding and capability to describe and model the processes which cause scintillation and time delay effects on Air Force systems.

Another goal of this research is the development of theoretical and/or specification models of electron density profiles on a global scale. Diagnostics include satellite and ionospheric sounder measurements and other ground based diagnostics. In the transport and particle precipitation dominated regions of polar cap, oval, and trough, research efforts are needed to concentrate on the development of an improved theory to determine auroral E-layer parameters from particle precipitation data are desired. Optical and radio remote sensing techniques are needed to measure electron density profiles, structures and plasma dynamics and drifts, as well as measurements of these and other relevant quantities as inputs to theory and modeling. At midlatitudes, research efforts are needed concentrate on development of ionospheric models and data processing codes to determine electron density profiles from satellite measurements of optical emissions.

Deficiencies in the ionospheric area are lack of understanding of polar ionospheric physics to define the generation, variability, and life cycles of medium- to large-scale (90-1000 km) ionospheric structures at high-latitudes, and lack of a relevant ionospheric data base. Also poorly understood are the relationships of polar cap convection and other geophysical quantities to trough development. Quantitative deficiencies also exist in current theories of plasma generation by particle precipitation, over the range extent of the E and F layer and difficulties in reliably extrapolating ionospheric specification models from limited data sets. Further lacking are data relating the influence of high-latitude processes and mesosphere -thermosphere coupling, including gravity waves and tides, on the physics and dynamics affecting neutral density distribution.

Dr Herbert C. Carlson, LIS (617-377-2458)

IONOSPHERIC DEFENSE TECHNOLOGY

The objective of this research area is to develop basic ionospheric modification technology as it applies to the enhancement or degradation of Air Force system performance. One segment of this program addresses chemical modification and the chemical processes of the normal and disturbed ionosphere. The research consists of laboratory measurements and quantum chemical calculations relevant to the chemical reactions of those ions and molecules that are either naturally present in the ionosphere or that could be artificially introduced to create an ionospheric perturbation. Measurements are made of kinetic or thermochemical parameters (e.g., reaction rate constants, bond dissociation energies, electron affinities, ionization potentials) required in understanding and predicting the effects of natural and artificial disturbances in the ionosphere. Some specific measurements planned include: (1) rate constants for electron attachment to metal oxides, metal carbonyls, and other organometallic compounds; (2) rate constants for ion-neutral association reactions generating the principal solvated ions in the lower atmosphere; and (3) determination of the electron detachment energies for the negative ions generated by electron attachment to selected organometallics. The research will also include a comprehensive study of D-region electron attachment to selected organometallics.

Another segment of the program is associated with a wide range of ground and space-based ionospheric enhancement technologies. Emphasis is on conducting the appropriate theoretical and experimental programs to assess the potential of various enhancement techniques for significantly helping Air Force C3 capabilities. The ground-based approaches include high power radiowaves over a broad frequency range from VLF through microwaves. Included in the space-based approaches are electron and ion beams, electron accelerators, x-rays, and chemicals. The effects of the various modification approaches on radiowave propagation should also be addressed. An additional objective of this research area is to develop the basic technology for determining the limitations imposed by the disturbed ionosphere on radio propagation over the LF through VHF frequency spectrum. The research will include a comprehensive study of D-region conductivity using small rocket payloads, LF ionosounding techniques, and satellite flux density measurements and ionospheric chemistry technology to examine the influence of the ionosphere on the behavior of ELF, VLF, and LF propagation during stressed ionospheric conditions such as would be caused by natural or nuclear events. At higher frequencies the effects of polar ionospheric disturbances on HF and VHF scatter propagation shall be investigated. In addition, ambient and perturbed F-region observations shall be made from the space shuttle. These data will be used to provide inputs to ionospheric models, especially the physical details of scintillation regions and to assess the gaseous contaminant cloud of the shuttle.
Theoretical and experimental programs to assess the potential for creating, maintaining and controlling artificial ionization in the atmosphere and/or ionosphere, with emphasis on ground-based, high power radiowave techniques are of interest. The characterization of the resulting ionization patches should include their radiowave reflection/scattering properties, so that the potential for exploiting artificial plasma technology for Air Force purposes can be assessed. In addition to creating artificial ionization, techniques for conditioning existing regions of the ionosphere also are of interest.

Mr John E. Rasmussen, LID (617-377-2109)

ATMOSPHERIC DENSITY AND SATELLITE DRAG

The objective of this research is to develop accurate methods of measuring the density of the atmosphere in the altitude range of 75 to 1500 km. In addition, since it is not always possible to make a density measurement at the geographical locations of interest (data denied areas) or at all times, it is necessary to develop highly accurate density models that can make these predictions. The major beneficiary of this density measurement and modelling program is the Space Track operation of Space Command, and the various program offices that are designing systems that are directly affected by atmospheric density (i.e. ICBM, re-entry systems, NASP). A tightly coupled goal is the development of a large-scale thermospheric global circulation model representing the coupled thermosphere-ionosphere system. Here the ultimate objective is to generate a dynamic model capable of forecasting accurately the neutral atmospheric density, winds, temperatures, and composition in the 90-1000 km altitude region. Satellite measurements of lower thermosphere density and dynamics, using accelerometers, mass spectrometers, Fabry-Perot interferometers, and ground-based lidar measurements are conducted for development of these new models.

Mr Frank A. Marcos, LIS (617-377-3037)

ULTRAVIOLET SURVEILLANCE AND REMOTE SENSING

The ultraviolet wavelength region extending from about 10 to 400 nanometers is important for an understanding of the ionospheric regions of the earth's atmosphere. Ultraviolet emission from and within the atmosphere can also be utilized to provide remote sensing capabilities to the Air Force that are presently not available. Radar and communications systems and missile surveillance systems operations can be improved through research directed toward finding remote sensing methods using ultraviolet radiation; which includes new electron density profile techniques, improved auroral disturbance region location identification, better knowledge of regions of radio wave scintillation, improved UV background models including variability, and improved knowledge of missile plume spectral and spatial extent in flight. New and improved ideas and approaches are sought in UV atmospheric radiance modeling, missile plume model applications, image analysis, and UV radiation physics of the ionosphere, including multiple-scattering effects.

Laboratory research work is of interest in the areas of laser-induced fluorescence of atmospheric species, cluster molecules and ions, theoretical spectroscopy, and electron-impact beam sources. Atmosspheric experimentation conducted at AFGL leads to interest in new sensors, improved imaging techniques for both ground and space use, improved filters, and improve calibration methods.

Dr Robert E. Huffman, LIU (617-377-3311)

AEROSPACE INSTRUMENTATION SYSTEMS

GENERAL OBJECTIVES: The goal of this research is to develop state-of-the-art improvements for specialized instrumentation for scientific balloon, sounding rocket and satellite flights. These flights are made to obtain scientific data in support of Air Force systems and for other DoD mission needs. The engineering instrumentation on these flights is for data retrieval, flight command-control, tracking and safety.

STATE-OF-THE-ART AEROSPACE INSTRUMENTATION

This flight instrumentation systems program is concerned with improving state-of-the-art capabilities for acquiring and storing data on-board the flight system. Areas integrated include: smaller data processing and storage devices, lower power consumption higher data acquisition rates and higher data capacities, and the development of a sea launch capability for large free-flying balloons. Improvements in the state-of-the-art ground instrumentation systems are developed in stationary and portable telemetry receiving, processing and tracking capabilities. Interest is in higher data acquisition rates, higher data capacities, simplified software for data display, innovative data base management techniques and higher tracking accuracies. Research is conducted to develop new techniques and systems to simulate the flight environment for pre-flight testing of payloads.

Mr C. Nealon Stark, LC (617-377-3004)

TERRESTRIAL EFFECTS ON AIR FORCE OPERATIONS

GENERAL OBJECTIVE: The general objective is to advance technology in the areas of geodesy, gravity, seismology, and geodynamics in a manner conducive to the resolution of Air Force problems in navigation, guidance, inertial testing, motion-sensitive instrumentation, and nuclear test monitoring. Within this objective there are two major thrusts: Geodesy and Gravity, and Solid Earth Geophysics. These thrusts constitute the missions of the two branches within the Earth Sciences Division.

GEODESY AND GRAVITY

The goal of this program is increased understanding of the nature of the Earth's gravity field, geodetic estimation techniques, geodetic reference systems, and gravity data processing techniques, and development of improved gravitational and inertial measurement systems. Specific areas of interest include, but are not limited to: improved solutions to the geodetic boundary value problem; optimal gravity estimation methods for large data sets; upward and downward continuation of gravity data; Earth rotation measurements and associated models for the Earth's interior; airborne and landvehicle gravity gradiometer data processing; balloon-borne gravimetry; spaceborne gravity and gravity related measurements (e.g., satellite-to-satellite tracking, satellite gradiometry); applications of gravitation theory; inertial and astronomic determination of position (azimuth, latitude, longitude); precise determination of baselines and position components using GPS or through other novel data acquisition techniques; measurement of gravity and gravity gradients at altitude supported by ground truth data; atmospheric refraction corrections for astro-measurement instruments; and relaxation and parallel processing techniques for geodetic adjustments.

Dr Thomas P. Rooney, LWG (617-377-3486)

⌄EISMO-ACOUSTIC ANALYSIS & MODELING

The goal of this program is increased understanding of the solid Earth environment to Air Force operations, facilities, and systems using a broad range of geophysical disciplines with particular emphasis on seismology. Strong emphasis is placed on distinguishing between natural and manufactured ground motion sources. Specific areas of interest include: (1) motions caused by natural and man-made phenomena; (Included are seismological, acoustical and tectonic studies. Diverse applications such as nuclear test detection, seismic communication, site characterization and facility damage assessment are considered here). (2) determination of earth motions caused by acoustic loading from a variety of sources such as missile launches and aircraft and engine testing. Determination of Earth structure from seismograms generated by earthquakes and explosive sources is a major task that is included in both areas. Techniques from exploration geophysics and classic seismology are drawn upon for this effort. Laboratory efforts include the application of numerical and physical models to problems in seismic source coupling and complex wave propagation and scattering in heterogeneous materials. Numerical modeling methods also are used to determine seismic source parameters for earthquakes or explosions based on regional and teleseismic waveforms.

Dr Henry A. Ossing, LWH (617-377-3222)

WEATHER IMPACT ON AIR FORCE MISSION

GENERAL OBJECTIVE: The general objective is to develop improved instrumentation and techniques for measuring, processing, analyzing, modeling, and predicting meteorological properties which impact the Air Force mission. Emphasis is on improved cloud physics, boundary layer, and weather simulation models for Air Force systems applications; improved global and regional numerical weather prediction models, automated mesoscale analysis and prediction techniques, and battlefield weather observing and forecasting techniques for Air Force operations applications; improved ground-based and airborne remote sensing and analysis techniques for weather hazard detection and warning; and improved satellite sensing and data analysis techniques for application to numerical weather prediction and three-dimensional cloud analyses.

WEATHER SENSING TECHNOLOGY

Atmospheric Sounding from Satellites

Effort is to develop techniques for the measurement of meteorological parameters from satellites. This includes the development of passive sensors and techniques as well as lidar and radar assessments for the three-dimensional global observation of meteorological parameters from satellites. The satellite data will then be incorporated into numerical weather prediction models in order to support strategic and tactical missions.

Satellite Cloud and Precipitation Technique Development

Involves the development of techniques to specify cloud and precipitation characteristics from global satellite observations. Supports strategic and tactical missions by defining the clear and cloudy atmosphere and regions of precipitation using data from meteorological satellites.

Remote Sensing of Weather Parameters

To develop the capability to have automated remote detection of atmospheric phenomena which affect Air Force operations and system development. This will include assessing sensors and techniques to detect present weather conditions, specifying atmospheric parameters affecting reentry vehicles, and characterizing microwave propagation conditions in clouds and precipitation.

Dr Kenneth M. Glover, LYR (617-377-4405)

ATMOSPHERIC CHARACTERIZATION TECHNOLOGY

Weather Simulation and Climatological Models

The goal is to generate synthetic climatologies by simulating weather events. To develop statistical models and simulation techniques to provide weather events, such as cloud scenes, which accurately reflect in space and time the climatology of the area. Then by repeated simulation, to obtain climatologies, e.g., cloud-free lines-of-sight and cloud-free sectors of sky.

Atmospheric Specification for Point Analysis

This research involves the production of scientific techniques, algorithms and data sets that will enhance the Improved Point Analysis Model (IPAM). These enhancements will increase the ability of IPAM to produce a realistic specification of the atmospheric conditions over a point on the earth.

Rain Rate Duration Models

To be developed are data sets and models describing the frequency, duration, and spatial distribution of 1-min rainfall rates. The data sets and models will be used to determine the impact of attenuation due to rain on satellite communications and other systems affected by attenuation or interference caused by rain.

Cloud Microphysics Specification

Data is being collected to provide the description and specification of cloud and precipitation types and particles sizes. This information will be used to improve the forecasts of reentry vehicle erosion, EHF communication degradation, and the losses of directed energy due to cloud and precipitation particles.

Mr Donald D. Grantham, LYA (617-377-2982)

ATMOSPHERIC PREDICTION TECHNOLOGY

Large-scale Modeling and Prediction

The research involves studies of the interaction among atmospheric physics processes important to cloud and moisture prediction and the development and testing of global and regional-scale numerical weather prediction (NWP) models. As such, there is a need for research into moisture physics (convective and stratiform), boundary layer processes, cloud radiation interactions, improved cloud-moisture conversion algorithms, the utilization and impact of satellite imagery and soundings, 4-D data assimilation methods, and refinements to NWP numerical procedures (e.g., finite difference, spectral).

Meso (Theater) Scale Modeling and Prediction

Meso scale modeling involves the determination of processes by which moist micro-physical atmospheric factors interact with theater-scale weather systems. These studies will lead to more accurate and more realistic NWP models applicable to weather support requirements in the 6-24 hr time frame. Relevant research studies are sought in mesoscale data assimilation, better understanding of specific mesoscale processes, diagnostic studies using ground-based remote sensors, and numerical methods pertinent to limited area models.

Airfield Weather Prediction Methods

The goal is to develop automated techniques that will include information processing, nowcasting, and very short-range forecasting techniques designed to use high resolution weather data from several emerging sensor systems (e.g. Doppler radar, GOES, DMSP, profilers). The system will provide forecasts of airfield and local area weather conditions, principally in the 0-6 hour time frame. Numerically based on advection, extrapolation, and simple and fast numerical modeling approaches are being considered as candidate terminal forecasting solutions. Artificial intelligence (expert systems) applications for information processing, event monitoring, and forecast assistance purposes are desired.

Mr Donald A. Chisholm, LYP (617-377-4729)

OPERATIONAL WEATHER SYSTEM (PROJECT 2688)

This 6.3 advanced development program encompasses several broad areas of support to Air Force Operational weather systems.

Pre-Strike Surveillance/Recon System (PRESSURS) a system is under development for the collection and transmittal of weather data from beyond the Forward-Line-of-Own-Troops (FLOT). Direct weather observations, supplementing satellite data, will permit battlefield commanders to incorporate weather early in their decision-making processes. The concept to be validated is the use of unmanned air vehicles.

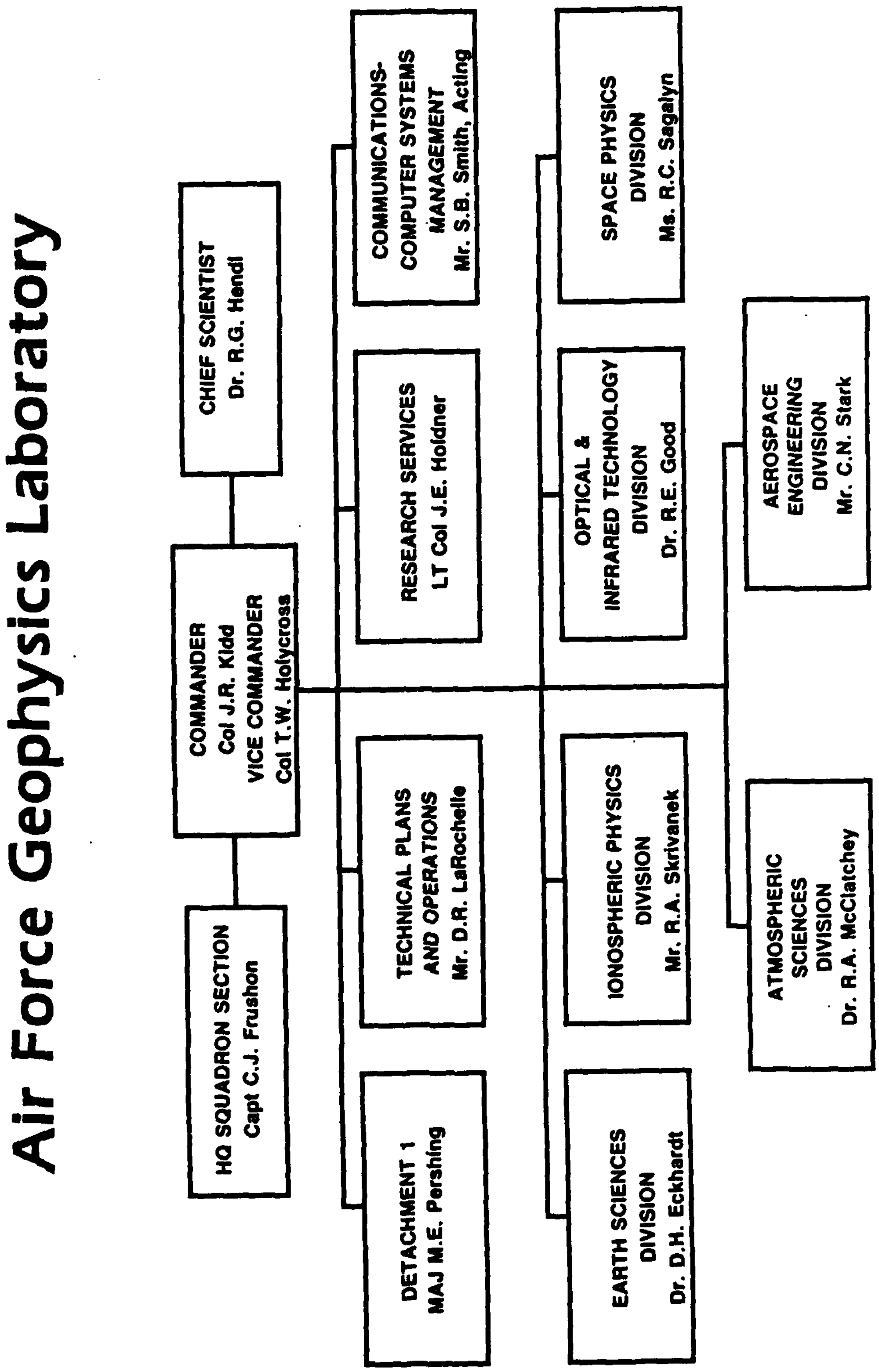
PRESSURS will consist of weather sensors, delivery vehicle, navigation capability, communications link, and a ground processing point.

Tactical Decision Aids (TDA) calls for system-specific forecasts of how weather will affect electro-optical (E-O) precision guided munition and target acquisition systems which operate in the visible, infrared (IR), laser, and millimeter wavelengths. Each TDA consists of models of specific sensor response, transmission of radiation through the atmosphere, and the response of targets and backgrounds to various weather elements. TDA inputs are conventional weather data and forecasts. The TDA outputs are weapon-specific performance values such as target acquisition range, lock-on range, target/background contrast. The PE63707 effort includes the development of the TDAs, their implementation in manual form and on calculators, and the integration of all TDAs into a small computer.

Automated Observing System (AOS), calls for the selection and test of meteorological sensors and techniques suitable for use in an automated weather observation system (AOS). The automation of aviation weather observations is needed in four broad problem areas. They are: 1) clouds, 2) visibility, 3) present weather, and 4) obstructions to vision. This program is selecting sensors, data assimilation techniques and algorithms to develop solutions for these problem areas. Tests are being performed to determine feasibility and to characterize performance. Assessments will be made to determine the capability of an instrument to perform in an automatic mode and to satisfy requirements for Air Force observations.

Dr. Michael Kraus, LYA (617-377-2475)

APPENDIX I


Air Force Geophysics Laboratory
CHIEF SCIENTIST
Dr. R.G. Hendl
COMMANDER
Col J.R. Kidd
VICE COMMANDER
Col T.W. Holycross
HQ SQUADRON SECTION
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COMPUTER SYSTEMS
MANAGEMENT
Mr. S.B. Smith, Acting
RESEARCH SERVICES
LT Col J.E. Holdner
TECHNICAL PLANS
AND OPERATIONS
Mr. D.R. LaRochelle
DETACHMENT 1
MAJ M.E. Pershing
SPACE PHYSICS
DIVISION
Ms. R.C. Sagalyn
OPTICAL &
INFRARED TECHNOLOGY
DIVISION
Dr. R.E. Good
IONOSPHERIC PHYSICS
DIVISION
Mr. R.A. Skrivanek
EARTH SCIENCES
DIVISION
Dr. D.H. Eckhardt
AEROSPACE
ENGINEERING
DIVISION
Mr. C.N. Stark
ATMOSPHERIC
SCIENCES
DIVISION
Dr. R.A. McClatchey

APPENDIX II

Facilities

AFGL is a tenant organizations located at Hanscom AFB, Massachusetts. In FY86, the AFGL Payload Test and Integration Facility at Hanscom AFB was completed for support of aerospace engineering testing of balloon, sounding rocket and shuttle payloads. In addition, AFGL has two NKC-135 flying laboratories instrumented for ionospheric and infrared research and three major field sites:

Weather Doppler Radar Facility, Sudbury, MA

Weather Test Facility, Otis AFB, MA

Detachment 1 (Balloon R&D Test Facility), Holloman AFB, NM

Also, AFGL has many data-collecting field sites in various remote locations which are operated full-time and manned part-time.

In addition to the above, AFGL in-house facilities include: rocket/balloon/satellite/-borne experiment data analysis and reduction facility; beam/plasma effects space simulation chambers; surface chemistry facility; shuttle-borne space environment interactions test bed; solar observatory; laser-induced chemistry facility; mass spectrometer calibration facility; UV calibration facility; ion/electron chemistry laboratory; ground-based upper atmosphere LIDAR probe facility; man-machine weather and satellite data interaction facility; seismic observatory; auroral/nuclear IR chemistry simulation chamber; chemically-induced IR emission simulation chamber; laser-induced nuclear simulation facility; fourier-transform IR spectroscopy facility; high-resolution IR spectroscopy facility; and general computational facilities include high speed access to a CRAY 2, CDC, and a Cyber 860.

APPENDIX III

How To Prepare a Proposal

Unsolicited proposals to conduct programs leading to the attainment of any of the objectives presented in this document may be submitted directly to an Air Force laboratory. However, before submitting a formal proposal, we encourage you to discuss your approach with the laboratory point of contact as identified after appropriate sections within this Technical Objectives Document. After your discussion or correspondence with laboratory personnel, you will be prepared better to write your proposal.

As stated in the "AFSC Guide for Unsolicited Proposals" (copies of this informative guide on unsolicited proposals are available by sending $3.50 to Air Force Systems Command/DAPE, Andrews AFB, Washington, DC 20334-5000), elaborate brochures or presentations are definitely not desired. The "ABCs" of successful proposals are accuracy, brevity, and clarity. It is extremely important that your submission be prepared to encourage its reading, to facilitate its understanding, and to impart an appreciation of the ideas you desire to convey. Specifically, your submission should include the following:

a. Name and address of your organization.

b. Type of organization (profit, nonprofit).

c. Concise title and abstract of the proposed research and the statement indicating that the submission is an unsolicited proposal.

d. An outline and discussion of the purpose of the research, the method of attack upon the problem, and the nature of the expected results.

e. Name and research experience of the principal investigator.

f. A suggestion as to the proposed starting and completion dates.

g. An outline of the proposed budget, including information on equipment, facility, and personnel requirements.

h. Names of any other Federal agencies receiving the proposal (this is extremely important).

i. Brief description of your facilities, particularly those which would be used in your proposed research effort.

j. Brief outline of your previous work and experience in the field.

k. If available, you should include a description brochure and a financial statement.

APPENDIX IV

Other Sources of Information

There are various sources for technical information produced by or for the United States Government and for notification concerning competitive procurement of research and development efforts leading to such information:

Source of Technical Information

- Unlimited Documents

National Technical Information Service (NTIS)
U.S. Department of Commerce
Springfield, VA 22151

NTIS announces the availability of government technical reports through two periodical lists: "Government Report Announcement" (GRA) and "Government Reports Index" (GRI). The NTIS sells unclassified, unlimited reports to the general public.

- Limited Documents

Defense Technical Information Center (DTIC)
Cameron Station
Alexandria, VA 22314

DTIC publishes a periodical listing of technical reports in its collection. This "Technical Abstract Bulletin" (TAB) is available to registered DTIC users.

Source of Information Concerning Government R&D Procurement

Commerce Business Daily

A U.S. Department of Commerce publication printed and mailed by the GPO, Chicago,IL.

For information and subscriptions contact:

Superintendent of Documents
Government Printing Office
Washington, DC 20402

Also, Broad Agency Announcement (BAA), an AFGL publication published annually in the Fall and available from AFGL/XOM, Hanscom AFB, MA 01731.